James Logan, an early contributor to the doctrine of sex in plants.

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No part of botany has so often engaged the pen of the historian as the doctrine of sexuality in plants, established by Rudolph Jacob Camerarius in his works collected by Johann Mikan, professor of botany in Prague, under the title Opuscula Botanici Argumenti. Before the year 1691, and after that date although to a less extent, the authority of the ancients was still great, for in the books of that time, the views of Aristotle, Empedocles and Theophrastus are constantly quoted in support of one theory or another. Even Camerarius insists that the opinion of the Greek authors on natural history is not opposed to his sexual theory. A perusal of the works of Grew, Ray, and Malpighi show how loath these botanists were to set up their opinions against the scholasticism of the middle ages. A historical retrospect interestingly shows that progress in botany, as in every science, was made spasmodically, and often in an uncertain and indirect way did the leaders in botanical thought break away from the scientific mysticism of the ancients.

The path forward was a long and tortuous one. The philosophical speculations, founded deductively on the hypothetical observation of nature, could only be set aside and a true science created in one way, namely that of experiment. The value of Camerarius's work lies in the fact that he for the first time attempted to solve the question and remove the difficulties which embarrassed the sexual theory by direct experiment. To the scanty knowledge concerning the date palm, the terebinth and the 'malus medici,' as given by Theophrastus, and the untrustworthy observations of Ray and Malpighi, Camerarius added much of value by his careful investigations.

Sachs, in his "History of Botany," after a full discussion of the matter, giving all honor to the scientific spirit of Camerarius, names him as the founder of the doctrine of sexuality in plants, and states further, that the botanists Bradley, Logan, Miller, and Gleditsch, were instrumental in adding much additional experimental proof. The purpose of this paper is

to show how far James Logan, an American and Philadelphian, contributed to lay the foundations of that doctrine which received its true scientific stamp from the hands of Joseph Kölreuter, Conrad Sprengel and Karl Friedrich Gärtner.

Philadelphia at the beginning of the eighteenth century stood for the excellence of science in America. Franklin, Bartram and Logan lived contemporaneously. It is to the little known writings of James Logan, an Irishman, governor of Pennsylvania, that I wish to advert. Sachs mentions him as one of the adherents and a founder of the sexual theory in plants, one of the first to determine by direct experiment the necessity of the pollen (farina) to the fecundation of the ova (ovules). The experiments were made to controvert the statements of M. Geoffroy in Miller's dictionary to the effect that by some experiments on maize, he (M. Geoffroy) was convinced that seeds may grow up to their full size and appear perfect to the eye without being impregnated by the farina (pollen). James Logan states in a letter to Peter Collinson, dated Philadelphia, Nov. 20, 1735, that he had reason to think otherwise.[1] His experiments were undertaken with a definite end in view, to test the truth of M. Geoffroy's statements.

The results of the experiments were given in brief in the letter to Peter Collinson, and later a full account was published in Latin in a work entitled, "Experimenta et Meletemata de Plantarum Generatione, etc., auctore Jacobo Logan, *Judice Supremo, & Praeside Concilii Provinciæ Pensilvaniensis in America.* Lugduni Batavorum. Apud Cornelium Haak 1739," pp. 3–13. (Preface dated Philadelphia 1737.)

Dr. Fothergill, the "J. F." of the English preface, translated the work of 1739 into English. The English version was published in London in 1747 under the title, "Experiments and Considerations on the Generations of Plants, translated from the Original Latin by J. F., London, printed for C. Davis, over against Gray's Inn Gate, Holborn, 1747." The Latin text appeared on one page, and opposite to it, on the other, the English translation. Sachs mentions both of these works, but was unable to consult them in the preparation of his history. Dr. Fothergill's preface to the English edition is worth quoting, as an introduction to Governor Logan's experiments.

[1] Phil. Trans., **34:** 192–195.

"The following essay in Latin was published at Leyden in 1739: It is now translated and reprinted here, that the sentiments contained in it may be submitted to more general consideration. Our author's address in choosing and conducting experiments, and his capacity for the abstrusest researches would doubtless have enabled him to have given to the world ample satisfaction on this intricate subject had he been permitted to prosecute his inquiries. But his country called him [Cincinnatus like] to more important affairs, and kept him constantly engaged in employments more immediately beneficial to society.

"The translator has endeavored to keep close to his author's sense. In point of expression, he fears, he often falls short of the original, the style whereof is nervous, concise and truly Roman. The Latin botanical terms are mostly retained, as we have not yet words in our own tongue to express the various parts of plants and flowers, which the growing science is obliged to describe, and to explain by terms adopted from other languages, etc. J. F."

The experiments, given in the quaint style of the period, speak for themselves.

"As several doubts had formerly occurred to me, in respect to the generation of both plants and animals, when I first heard of the *farina foecundans*, or impregnating male dust, I conceived great hopes that these would be easily solved, and the whole of this intricate affair receive considerable light from the discovery. And as I had long ago observed with surprize, the singular way of growth of our Indian wheat or maize, I judged it, of all plants I had seen, or perhaps of any that nature produces, the most proper one for experiments of this kind. Indian wheat grows to the height of six, eight and sometimes ten feet. At the top of the stalk, it bears a thready tuft or tassel (called by Malpighi muscarium), furnished with apices [anthers] which yield the farina. From the joints of the stalks below, the ears grow out, which are six, eight, ten and sometimes even twelve inches long. These consist of a pretty solid substance, about an inch thick, set quite around with grains regularly disposed in rows, in a very beautiful manner. Generally there are eight such rows, often ten, sometimes twelve, and I once saw sixteen. There are commonly forty grains in each row, more or less; which in their first rudiments, and whilst the stalk they grow upon is

soft and tender may justly be called the ova or eggs. To each ovum, there adheres a white, fine, smooth filament, which excepting that it is hollow, resembles a thread of silk. These filaments are disposed, one by one, in order, betwixt the rows from that end where the ear rises from the stalk to the other, where they creep from under the base, that encloses the ear, and make their appearance, in the open air, in a bundle or skein. Their color in this part is mostly whitish, though sometimes a little yellow, red or purple, according to the nature of the plant they grow from. These filaments, as I formerly suspected are the real styles of the eggs.

"Intending, therefore, to make some experiments on this plant, towards the end of April, I planted four or five grains on hillocks, as is usual in sowing maize, in each corner of a little garden I had in town, which was forty feet wide and eighty feet long. About the beginning of August, when the plants were full grown, and the tufts on the top, and the ears on the stem had acquired their full extent, I cut off these tufts from every plant on one hillock. On another without meddling with the tufts, I gently opened the leaves that covered in the ears, and cut away from some all the styles and then closed the leaves again; from others a quarter part, from others one half, and from others three quarters, and left the rest untouched. I covered another ear, before the skein of styles appeared out of the case, with a piece of very fine, soft muslin, but so loosely, that its growth could not be injured, and whilst the fuzzy texture of the muslin suffered it to receive all the benefit of the sun, air and showers, the farina was effectually secluded. I left the plants on the fourth hillock, as I did these except in the circumstances above mentioned, unmolested till they were fully ripe.

About the beginning of October, when it was time to inquire into the success of my experiments, I made the following observations. In the first hillock, where I had cut off all the tufts, the ears whilst they remained covered with their husks, looked indeed very well, but were small, and felt light when handled; and not one perfect grain to be found in them, except in one large ear, which grew out somewhat farther from the stalk than usual, and on that side too which faced another hillock in a quarter from whence our strongest winds most commonly blow. In this ear alone, I found about twenty grains which were full grown and ripe. I attributed

this to the farina brought by the wind from a distant plant. In those ears from which I plucked off some of the styles, I found just so many ripe grains as I had left styles untouched. In those covered with muslin, not one ripe grain was to be seen. The empty or barren eggs were nothing but mere dry husks.

"From these experiments, which I made with the utmost care and circumspection, as well as from those made by a great many other persons, it is very plain, that this farina emitted from the summits of the styles, is the true male seed, and absolutely necessary to render the uterus and grain fertile, a truth which however certain, yet was not known till the present age. The discoverer of this grand secret of nature ought ever to be remembered with due applause. Sir Thomas Millington, sometime Savilian professor, seems first to have taken notice of it, before or about the year 1676 [simply a conjecture without experimental proof] according to the account which Dr. Grew gave in a lecture read before the Royal Society the 9th of November the same year (see Grew's Works p. 161, 171). Malpighi nowhere that I know of, mentions its use. And Grew himself, though he allows it necessary for fecundation, yet did not suspect that it entered the uterus: but S. Morland about twenty years after, asserted that it entered the uterus through the canal of the style (see Phil. Trans. No. 287). I once saw a small grain in the middle of this canal; nor is it to be doubted, but that stricter inquiries will discover more of them passing the same way."

In another paragraph, Logan seems to presage the discovery of the fact that nature abhors continuous self-fertilization by providing many adaptive floral arrangements. He says: "Not only in this plant, in nut bearing trees, reeds, in all the tribe of gourds, as pompions, melons, cucumbers, etc., in which the male and female parts of generation are separately placed, but also in most of those flowers which from both parts being placed within the same flower-cup, are by some called hermaphrodites, the apices are so situated that after the farina is perfected, they can seldom, if ever, touch the summit of the style or os uteri. But in these, as well as in such where the organs are separately placed, the farina must of necessity, after it is thrown off from the apices, float in the circumambient air and be subject to the hazard of not reaching the os uteri, and performing its office there," etc.

Another observation of his is quite modern in its view: "There is likewise farther to be observed in the maize, that on the same day when the apices burst and hang loosely waving in the air, the skein or bundle of styles appear from under the husk or sheath that covers the ear, and are in like manner exposed. This circumstance should put us upon observing what happens in this respect to other plants."

It is certainly to be regretted that Governor Logan did not observe what happens in other plants, but gave his time and attention to state affairs, for much that Sprengel afterwards made known might have been unraveled by him. His experiments might pass for those of the present age, but unfortunately he did not confine himself to recording facts pure and simple, but in the latter part of his paper wandered off into disquisitions on the nature philosophy of his day. The following explanation of Logan's to account for the sexual process smacks of medieval scholasticism.

He states boldly, that his observations are in support of the doctrine of sexes in plants, and that "there is room to apprehend that this [Logan's] hypothesis concerning generation will be readily adopted by posterity." "The farina is committed to the air, that it may receive out of the air, the little seed or plant, pre-existent and completely formed, tho' in stamina inconceivably minute and invisible; and thus becomes pregnant thereby." "It is drawn by an inherent attractive force first into the style, and through that it slides by proper canals to the ova, and from this farina, nourished by the juices of the plant for the purposes above described, the bulk of the seed is formed. Lastly the little plant hid in the seed and clothed with a terrestrial matter, which it borrows from the farina, exerts itself, and, increasing by proper nutriment, which it draws from the earth, at length springs up."

One is reminded of the theory of evolution of Claude Perrault and of his "aura coelestis" of the opinions of Wollaston and Varro. Logan, although he had worked at the matter experimentally was unable altogether to throw off the shackles of scholasticism. So much is a man influenced by the age and time in which he lives. Nevertheless, Governor Logan deserves more than a passing mention in any future discussion of the sexual theory of plants.

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